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AUTHOR Pugh, Richard C.; Hu, Yuehluen
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ABSTRACT

The use of terms to describe and interpret results from canonical correlation analysis has been inconsistent across research studies. This study assembled the terminology related to the use and interpretation of canonical correlation analysis from research articles, textbooks, and computer manuals. Research articles using canonical correlation were culled from the "Journal of Educational Research" from 1978 to 1989. At least 10 textbooks on multivariate analysis and the computer manuals for the Statistical Analysis System program and the Statistical Package for the Social Sciences (SPSS-X) were reviewed. There was considerable inconsistency in the use of the terminology in research articles, textbooks, and computer manuals. To address this confusion, a 69-item dictionary/thesaurus is presented; 32 of the terms include definitions and the remaining terms are cross-referenced to these terms. A 51-item list of references is included. (Author/SLD)

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CANONICAL CORRELATION: TERMS AND DESCRIPTIONS

Richard C. Pugh and Yuehluen Hu

School of Education, Indiana University, Bloomington

Smith Research Center
School of Education
Indiana University
Bloomington, IN 47405

Paper presented at the annual meeting of the Mid-Western Educational Research Association, Chicago

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CANONICAL CORRELATION: TERMS AND DESCRIPTIONS

Abstract

The use of terms to describe and interpret results from canonical correlation analysis has been inconsistent across research studies reporting the results of canonical correlation analysis. Computer manuals and textbooks have also varied in the use of terminology. Therefore, the purposes of this study were (1) to assemble the terminology utilized in the use and interpretation of canonical correlation analyses reported in research articles, textbooks, and computer manuals and (2) to develop a dictionary and thesaurus of cross-referenced terms. Research articles using canonical correlation analysis in the Journal of Educational Research from 1978 to 1989, at least ten multivariate textbooks, and the SAS and SPSSx computer manuals were reviewed. There was not consistency of the use of terms for the same concepts across these sources. There was evidence that attempts have been made to reduce confusion by the renaming of terms. A dictionary of 32 defined/described terms along with a thesaurus of 69 cross-referenced terms was developed.

Canonical Correlation: Terms and Descriptions

> ". . .one researcher's canonical loading becomes another's canonical weight; canonical dimension to one is a canonical variate to another; and, canonical correlation is the relationship between data sets for one, but only the relationship between variates for another."
>
> ---Wood & Erskine (1976)

Canonical correlation analysis procedures are readily available for educational researchers through the use of computer software packages such as SPSSx and SAS. Most all parametric significance tests, both multivariate and univariate, are special cases of canonical correlation analysis (Knapp, 1978). The relationship of canonical correlation analysis to other statistical procedures is described by Marascuilo and Levin (1983) in their multivariate textbook. They list eleven special cases of canonical analysis that demonstrate its connection to various statistical models. Among the special cases are simple correlation, simple and factorial ANOVA, ANCOVA, discriminant analysis, and factorial MANOVA. Given the versatility of the model, Marascuilo and Levin (1983) entertained the question about the teaching of the common statistical techniques using the canonical correlation analysis model. In general, they concluded that students should probably not be taught these common statistical techniques using canonical correlation analysis because most analyses are not conducted this way and because there would be increased demands place on students to use matrix algebra.

Nevertheless, the model has much appeal. Thompson (1988) describes canonical correlation analysis as a powerful method that frequently best honors the complex nature of the reality about which the researcher wished to generalize. The supplementary analyses that are now available permit the researcher to interpret a multitude of results from a multivariate context capitalizing on the covariation among dependent variables rather than proceeding with univariate techniques and ignoring the covariation. Researchers continue to be intrigued with the model studying such topics as the effects of rotation of matrices to enhance the interpretation of results (Jones, 1989), performing factorial MANOVA using canonical correlation analysis (Zinkgraf, 1983), and detecting interaction effects using canonical correlation analysis (Kirby & Abernathy, 1987) to name just three.

Yet, surveys of its use do not agree whether the model is being increasingly applied to many educational research problems. Wood and Erskine (1976) found that canonical correlation analysis was increasingly applied in the behavioral sciences and reviewed 30 applications of the method from 1965 to 1976. In contrast, L. D. Goodwin and W. L. Goodwin (1985a, 1985b) for the period of 1979 to 1983, found only three applications in the Journal of Educational Psychology and only three in the American Educational Research Journal. West, Carmody and Stallings (1983) found only one application in the Journal of Educational Research in the year 1970 and one application in 1980. Pugh (in press) found ten applications

of the model in the Journal of Educational Research over the eleven year period from 1978 to 1989.

In 1976, Wood and Erskine found incomplete use of the canonical correlation analysis method and confusion in its terminology. One purpose of this paper is to assemble the terminology utilized in published research articles, textbooks, and computer manuals. A second purpose is to help clarify the interpretation of results by developing a dictionary and thesaurus of terms.

Method

All articles published in the Journal of Educational Research from 1978 to 1989 were searched by scanning each article for canonical correlation analysis. Canonical correlation analysis was considered to be the generation of canonical variates in order to describe the relationships between two sets of variables. All terms related to canonical correlation analysis that were reported in the method, results, and discussion sections of each article were recorded and identified with the various components of the canonical correlation model.

Secondly, at least ten multivariate textbooks that devoted several pages (i.e., in several of the textbooks an entire chapter was devoted to the topic) to the topic of canonical correlation analysis were reviewed to identify terms and descriptions that were used in the presentation of the model. The SPSSx and SAS manuals were reviewed. And finally, several articles and papers related to

canonical correlation analysis identified through a search of the ERIC CIJE and RIE computer files using canonical correlation as a descriptive term were reviewed.

Results

There was ample evidence available to account for the inconsistency in the use of the terminology in research articles. There was not consistency of terms for the same concepts across textbooks and computer manuals. While for a majority of the references "weights were weights" and "loadings were loadings", there was evidence that attempts have been made to reduce confusion by the renaming of terms (e. g., using terms such as function coefficient and structure coefficient). To help clarify and to address the confusion found in the use of terminology, a dictionary of 33 defined/described terms along with a thesaurus of 69 cross-referenced terms was developed.

Terms and Their Descriptions
Used in Canonical Correlation Analysis:
A Dictionary and Thesaurus

Most terms are cross-referenced to other terms which have similar meanings. The cross-referencing is indicated by (1) a listing of other terms following the definitions/descriptions, and (2) by separately listing every term. Rather than repeating definitions/descriptions for terms that have similar meaning, the definitions/descriptions appear only once with the term which appeared to have the most consistent usage in our review. For terms without definitions/descriptions, a simple reference (e. g., See Adequacy coefficient.) is made to the term with the definitions/descriptions.

Adequacy coefficient

1. The average of all the squared structure coefficients for the original variables in one set with respect to one canonical variate. 2. Provides information as to how much of the variance in the original variables, on the average, is contained within the canonical variate scores for that variate. 3. Shows how "adequately" a canonical variate reflects the variance of the original variables. 4. Equal to 1.00 when a canonical variate captures 100 percent of the variance of the original variables. (Chacko, 1986; Thompson, 1980, 1984, 1988)

Other terms: Average squared loading (Tabachnick & Fidell, 1989);
Variate adequacy coefficient (Chacko, 1986; Thompson, 1980, 1984, 1988).

Average squared loading

See Adequacy coefficient.

Bartlett's Chi-square approximation

1. A general test of the hypothesis that the squared canonical correlation coefficients equal zero based on Wilk's lambda criterion, the amount of unexplained variance. 2. A test of the omnibus no-relationship hypothesis, based on P pairs of canonical variates where P is the smaller number of original variables in the two sets. (Bartlett, 1941; Levine, 1977; Marascuilo & Levin, 1983; Tatsuoka, 1988; Thompson, 1984)

Other terms: Bartlett's test.

Bartlett's test

See Bartlett's Chi-square approximation.

Canonical coefficient

See Canonical weight.

Canonical commonality analysis

See Commonality analysis.

Canonical component loading

See Structure coefficient.

Canonical Correlation

1. A multivariate technique used to assess the linear relationships between two sets of variables in which each set contains more than one variable. 2. The Pearson product-moment correlation coefficient, which ranges in value from 0.0 to +1.0, between the canonical variate scores of subjects on a given canonical function. 3. The maximal simple correlation of linear combinations of variables from the two sets. 4. The measure of strength of association when there are multiple criteria and multiple predictors. 5. The degree of relationship between a set of predictor variables and a set of outcome variables. (Bartlett, 1941; Finn & Mattsson, 1978; Harris, R. J., 1975; Hotelling, 1936; Newman, 1988; Thompson, 1980, 1987, 1988)

Other terms: Canonical correlation coefficient.

Canonical correlation analysis

1. The examination of the relationships between two sets of variables by deriving linear combinations of variables from each of the two sets so that the correlation between the two sets is maximized. 2. The identification of the "components" of one set of variables that are most highly related (linearly) to the "components" of the other set of variables. 3. The selection of linear functions that have maximum covariances across the two sets of variables. (Cooley & Lohnes, 1971; Darlington, Weinberg, & Walberg, 1973; Jones, 1989; Kerlinger & Pedhazur, 1973; Tatsuoka, 1988; Thompson, 1980, 1984)

Other terms: Canonical variate analysis and abbreviated CVA (Darlington et al., 1973; Jones, 1989)

Canonical correlation coefficient

See Canonical correlation.

Canonical correlation coefficient squared

1. The proportion of variance linearly shared between two canonical variates derived from the two sets of variables for a given canonical function. 2. The proportion of variance shared by two sets of variables which have been weighted by function coefficients so that the canonical correlation will be maximized. (Thompson, 1980, 1984)

Canonical cross-validation

See Invariance analysis.

Canonical function

1. Least square estimates obtained from the two sets of variables for exactly two canonical variates. 2. Unless rotated, a canonical function is always perfectly uncorrelated with every other function identified in an analysis. 3. The number of canonical functions derived from a data set is equal to the number of variables in the smaller of the two variable sets. (Thompson, 1980, 1984)

Canonical index coefficient

See Index coefficient.

Canonical loading

See Structure coefficient.

Canonical redundancy analysis

1. Examines how well the original variables can be predicted from the canonical variates. (SAS, 1985)

Canonical structure coefficient

See Structure coefficient.

Canonical variables

See Canonical variates.

Canonical variable loading

See Structure coefficient.

Canonical variate-variable correlation

See Structure coefficient.

Canonical variates

1. Least square estimates from each of the two sets of variables. The zero-order correlation between a pair of canonical variates is the canonical correlation coefficient.
2. Linear combinations of variables from each of the two sets.
(Bock, 1975; Cliff & Krus, 1976; Cohen & Cohen, 1975; Hall, 1969; Hotelling, 1936; Morrison, 1967; Tabachnick & Fidell, 1989; Tatsuoka, 1988; Timm, 1975; Wood & Erskine, 1976)

Other terms: Canonical variables
(Marascuilo & Levin, 1983; SAS, 1985);
Components
(Tatsuoka, 1988);
Composite variables,
(Thompson, 1987, 1988, 1989);
Derived variables
(Kachigan, 1982);
Linear combinations
(Tatsuoka, 1988);
Linear composites
(Darlington et al., 1973; Finn, 1974; Finn & Mattsson, 1978);
Linear compounds
(Morrison, 1967);
Synthetic variables
(Thompson, 1987, 1988, 1989);
Weighted averages
(Darlington et al., 1973).

Canonical variate analysis

See Canonical correlation analysis.

Canonical variate coefficient

See Canonical weight.

Canonical weight

1. Refers to either raw score weights or standard score weights used in the generation of canonical variate scores. Used to maximize linear relationships between two sets of variables. (Cliff & Krus, 1976; Darlington, 1973; Finn, 1974; Marascuilo & Levin, 1983)

Other terms: Canonical coefficient (SAS, 1985); Canonical variate coefficient (Thompson, 1980); Regression weight (Thorndike, 1978).

Commonality analysis

1. Indicates how much of the explanatory power of a variable is "unique" to a given variable and how much of its explanatory power is "common" to or also available from one or more other variables. "Unique" contribution of a variable is the variance attributed to it when it is entered last in a regression equation. 2. Methods of partitioning the ability of the variables of the set to account for the variables in the other set. 3. Useful in research studies in which at least one of the variable sets consists of variables that are conceptually or theoretically distinct. (Kerlinger & Pedhazur, 1973; Thompson, 1988; Thompson & Miller, 1985)

Other terms: Canonical commonality analysis, Components analysis, Element analysis (Thompson & Miller, 1985).

Communality coefficient

1. The proportion of an original variable's variance which is reproducible from the canonical variates calculated for its domain. 2. Sum of all the squared structure coefficients for an original variable. (Chacko, 1986; Jones, 1989; Thompson, 1980, 1982, 1984; Tatsuoka, 1988)

Components

See Canonical variates.

Components analysis

See Commonality analysis.

Composite variables

See Canonical variates.

Criterion variates

1. Canonical variates of the dependent set. (Hotelling, 1935)

Derived variables

See Canonical variates.

Element analysis

See Commonality analysis.

Function coefficient

See Standardized weight.

Hotelling-Lawley test

1. A test of the hypothesis that the sum of the squared correlation coefficients is equal to zero based on the Hotelling-Lawley criterion. 2. Involves taking the simple sum of the eigenvalues. (Marascuilo & Levin, 1983) 3. Pools the statistics from each canonical function to test the relationship between the two sets of variables. 4. The pooled ratio of effect variance to error variance. (Tabachnick & Fidell, 1989)

Index coefficient

1. The correlation between an original, unweighted variable in one set and a canonical variate in the other set, once the variables in the other set have been weighted by their function coefficients. 2. When squared, indicates the proportion of variance which an original variable from one set shares with the canonical variate established by a linear combination of the original variables of the other set. 3. Ranges in value from -1.0 to +1.0 inclusive. (Frankiewicz & Merrifield, 1967; Thompson, 1984, 1987, 1988; Thompson & Frankiewicz, 1979)

Other terms: Canonical index coefficient (Frankiewicz & Merrifield, 1967; Thompson & Frankiewicz, 1979).

Index coefficient squared

1. The proportion of variance which an original variable in one set linearly shares with a canonical variate in the other set. 2. The sum of the squared index coefficients for all variables in one set will equal the other set's redundancy coefficient. (Thompson, 1980)

Invariance analysis

1. An analysis performed separately on each of two subsamples in which a study sample has been divided, and the results are compared. 2. An attempt to determine how stable statistical results are likely to be across different samples. (Fish, 1986)

Other terms: Canonical cross-validation (Wood & Erskine, 1976).

Invariance coefficient

1. The product moment correlation coefficient between two canonical variate scores that are generated as follows: After randomly splitting a sample into two invariance subsamples, the two canonical variate scores for a given canonical function are computed by multiplying the predictor and criterion original variable standard scores of each individual in one subsample by the appropriate canonical function coefficients from the other subsample and summed to yield the two canonical variate scores. The product-moment correlation between the two canonical variate scores is the invariance coefficient. (Fish, 1986; Thompson, 1984; Thorndike, 1978)

Other terms: Invariance correlation coefficient (Fish, 1986).

Invariance correlation coefficient

See Invariance coefficient.

Interaction effects

1. The unique effect of two or more variables in one set which in combination affect the variables in the other set.
2. Implied whenever structure coefficients are not equal to function coefficients. (Kirby & Abernathy, 1987; Thompson, 1984; Thompson & Miller, 1985)

Linear combinations

See Canonical variates.

Linear composites

See Canonical variates.

Multivariate stepwise regression analysis

See Stepwise canonical analysis.

Pattern matrix

1. Vectors of standardized weights for the canonical variates. (Marascuilo & Levin, 1983)

Pillai-Bartlett test

1. A test of the hypothesis that the squared canonical correlation coefficients equal zero based on the Pillai-Bartlett trace criterion. 2. Involves taking the sum of each eigenvalue divided by 1 + the eigenvalue. (Marascuilo & Levin, 1983) 3. Pools the statistics from each canonical function to test the effect. 4. The pooled effect variances. (Tabachnick & Fidell, 1989)

Pooled redundancy coefficient

1. The sum of the redundancy coefficients across the various solutions is a measure of the share of the total trace of one set accounted for by the several solutions. 2. Equal to the sum of the redundancy coefficients for a given set. 3. For a given variable set, is equal to the average squared multiple correlation for that set. (Levine, 1977; Thompson, 1988)

Rao's F approximation test

1. A test of the hypothesis that the squared canonical correlation coefficients equal zero based on Wilk's lambda criterion. 2. Tests the same hypothesis as Bartlett's chi-square approximation and is generally preferred because it is a closer approximation to the exact distribution of Wilk's lambda criterion. 3. Like Bartlett's chi-square approximation, considers all of the canonical correlations simultaneously. (Marascuilo & Levin, 1983; SAS, 1985; Tatsuoka, 1988)

Redundancy coefficient

1. The share of the variance of one variable set which can be accounted for by a canonical variate from the other set.
2. For a given variable set, a redundancy coefficient is equal to the product of the squared canonical correlation and the proportion of that set's variance contained in its variate.
3. For a given variable set on a given function, equals the adequacy coefficient for the set times the square of the canonical correlation coefficient for that function. (Stewart & Love, 1968; Tatsuoka, 1988; Thompson, 1984, 1988)

Other terms: Redundancy index (Stevens, 1986; Timm, 1975; van den Wollenberg, 1977).

Redundancy index

See Redundancy coefficient.

Regression weight

See Canonical weight.

Rotation

1. Refers to the rotation of canonical components which may involve the single rotation of all components, the separate rotation of each set, or the sequential rotation of one set then the other. Involves both between-set and within-set relationships. Has as an objective, the simplicity of structure and increased clarity. (Thorndike, 1976)
2. Procedures which have as a purpose the improvement of the conceptualization and interpretation of canonical variates. To provide a better theoretical summary of the results. Unlike canonical correlation analysis in which there is no correlation within and between sets of unrotated canonical variates except for the single pairwise linkage of one variate from one set to the corresponding variate of the other set on a given function, after rotation the variates in each set will be correlated to the variates in the other set. The off-diagonal elements in the canonical correlation matrix will no longer be exactly zero. Either function or structure coefficients have been used as elements in the canonical correlation matrix to be rotated but evidence tends to favor the use of structure coefficients. (Jones, 1989)

Roy's test

1. Procedure for testing the hypothesis that the first canonical correlation coefficient is equal to zero. (Marascuilo & Levin, 1983)

Standardized canonical coefficient

See Standardized weight.

Standardized coefficient

See Standardized weight.

Standardized function coefficient

See Standardized weight.

Standardized weight

1. A standardized weight applied to an original variable to optimize the linear relationship between the two sets of variables. 2. A standardized weight that is a partial regression coefficient, analogous to a beta weight in multiple regression analysis and to a pattern coefficient in factor analysis. 3. The interpretation of a canonical variate by reference to these weights may be unstable due to high multicollinearity effects. (Bock, 1975; Darlington et al., 1973; Marascuilo & Levin, 1983; Thompson, 1984, 1987, 1988)

Other terms: Function coefficient (Thompson, 1984, 1987, 1988); Standardized canonical coefficient (SAS, 1985; SPSSX, Inc., 1988); Standardized coefficient (Stevens, 1986); Standardized function coefficient (Thompson, 1987).

Sequential Bartlett analysis

1. A procedure for deciding how many canonical variate pairs should be retained following a canonical correlation analysis. 2. Based on the partitioning of the Bartlett Chi-square statistic. 3. Analogous to the backward elimination method of multiple regression where reductions in the multiple correlation squared are examined as variables are dropped from the model. (Marascuilo & Levin, 1983)

Step-down analysis

See Stepwise canonical analysis.

Stepwise canonical analysis

1. A procedure to find a reduced set of variables that will predict the criterion almost as well as the full set of predictors. 2. A procedure (e. g., selecting variables with the smallest communality coefficients) to eliminate variables which do not contribute to the relationship between the two sets. (Thorndike, 1978; Thorndike & Weiss, 1973) 3. Called step-down analysis when variables are selected theoretically. (Darlington et al., 1973; Roy, 1958) 4. Called multivariate stepwise regression analysis when variables are selected mechanically. (Darlington et al., 1973; Bock & Haggard, 1968).

Other terms: Multivariate stepwise regression analysis (Bock & Haggard, 1968; Darlington et al., 1973); Step-down analysis (Darlington et al., 1973; Roy, 1958).

Structure coefficient

1. Bivariate correlation coefficient between an original variable and the composite or canonical variate involving the variable set to which the variable belongs. 2. A zero-order correlation between a canonical variate and one of its constituent variables. 3. The correlation between an original variable and the canonical variate defined by the variate coefficients of all the variables in the same set. 4. The most helpful coefficients to consult when interpreting canonical results. (Cohen & Cohen, 1975; Cooley & Lohnes, 1971; Levine, 1977; Thompson, 1987, 1988, 1989)

Other terms: Canonical component loading (Thorndike, 1978); Canonical loading (Wood & Erskine, 1976); Canonical structure coefficient (Jones, 1989); Canonical structure correlation (SAS, 1985); Canonical variable loading (Tabachnick & Fidell, 1989); Canonical variate-variable correlation (Stevens, 1986). Structure correlation (Cliff & Krus, 1976).

Structure coefficient squared

1. The proportion of variance that an original variable linearly shares with its canonical variate or composite. (Chacko, 1986; Thompson, 1980, 1984)

Structure correlation

See Structure coefficient.

Structure matrix

1. The matrix of correlations of the original variables of a given set with the canonical variates of the same set. 2. Vectors of correlation coefficients between the original variables and the canonical variates within the same set. (Levine, 1977; Marascuilo & Levin, 1983)

Synthetic variables

See Canonical variates.

Variate adequacy coefficient

See Adequacy coefficient.

Trace

See Trace coefficient.

Trace coefficient

1. The positive square root of the sum of the squared canonical correlations divided by the number of variables in the dependent set. 2. Interpreted as the portion of the generalized variance of the dependent set accounted for by the systematic portion of the reduced form of the complete system of equations. 3. The trace coefficient ranges from zero to one. (Levine, 1977)

Other terms: Trace (Levine, 1977).

Weighted average

See Canonical variates.

Wilks' Lambda

1. A likelihood ratio statistic that tests the likelihood of the data under the assumption of all population canonical correlation coefficients are equal to zero. 2. Pools the statistics from each canonical function to test the relationship between the two sets of variables. 3. The pooled ratio of error variance to effect variance plus error variance. (Tabachnick & Fidell, 1989)

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